



## **Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes<sup>1</sup>**

This standard is issued under the fixed designation A 213/A 213M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

---

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.10 on Stainless and Alloy Steel Tubular Products.

Current edition approved—Oct. March 1, 2003. Published—January April 2004. Originally approved in 1939. Last previous edition approved in 2003 as A 213/A 213M – 03e2.

## 1. Scope\*

1.1 This specification<sup>2</sup> covers minimum-wall-thickness, seamless ferritic and austenitic steel boiler, superheater, and heat-exchanger tubes, designated Grades T5, TP304, etc. These steels are listed in Tables 1 and 2.

1.2 Grades containing the letter, H, in their designation, have requirements different from those of similar grades not containing the letter, H. These different requirements provide higher creep-rupture strength than normally achievable in similar grades without these different requirements.

1.3 The tubing sizes and thicknesses usually furnished to this specification are  $\frac{1}{8}$  in. [3.2 mm] in inside diameter to 5 in. [127 mm] in outside diameter and 0.015 to 0.500 in. [0.4 to 12.7 mm], inclusive, in minimum wall thickness. Tubing having other dimensions may be furnished, provided such tubes comply with all other requirements of this specification.

1.4 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. The inch-pound units shall apply unless the "M" designation of this specification is specified in the order.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

~~A 450/A 450M Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes~~

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys and Ferroalloys

A 1016/A 1016M Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes

E 112 Test Methods for Determining Average Grain Size

E 527 Practice for Numbering Metals and Alloys (UNS)

### 2.2 Other Standard:

SAE J1086 Practice for Numbering Metals and Alloys (UNS)<sup>4</sup>

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology A 941.

## 4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for products under this specification. Such requirements to be considered include, but are not limited to, the following:

4.1.1 Quantity (feet, metres, or number of lengths),

4.1.2 Name of material (seamless tubes),

4.1.3 Grade (Tables 1 and 2),

4.1.4 Condition (hot finished or cold finished),

4.1.5 Controlled structural characteristics (see 6.3),

4.1.6 Size (outside diameter and minimum wall thickness),

4.1.7 Length (specific or random),

4.1.8 Hydrostatic Test or Nondestructive Electric Test (see 10.1),

4.1.9 Specification designation and year of issue,

4.1.10 Increased sulfur (for machinability, see Note-A, B, Table 1, and 14.3), and

4.1.11 Special requirements and any supplementary requirements selected.

## 5. General Requirements

### 5.1 Material

5.1 Product furnished to this specification shall conform to the requirements of Specification ~~A 450/A 450M, A 1016/A 1016M~~, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification ~~A 450/A 450M, A 1016/A 1016M~~ constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification ~~A 450/A 450M, A 1016/A 1016M~~, this specification shall prevail.

## 6. Materials and Manufacture

6.1 *Manufacture and Condition*—Tubes shall be made by the seamless process and shall be either hot finished or cold finished, as specified. Grade TP347HFG shall be cold finished.

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-213 in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

**TABLE 1 Chemical Composition Limits, %<sup>A</sup>, for Low Alloy Steel**

| Grade | UNS Designation | Carbon    | Manganese | Phosphorus | Sulfur             | Nickel    | Chromium | Molybdenum | Vanadium  | Boron     | Niobium       | Nitrogen  | Aluminum    | Tungsten | Titanium  | Other Elements |
|-------|-----------------|-----------|-----------|------------|--------------------|-----------|----------|------------|-----------|-----------|---------------|-----------|-------------|----------|-----------|----------------|
| T2    | K11547          | 0.10–0.20 | 0.30–0.61 | 0.025      | 0.025 <sup>B</sup> | 0.10–0.30 | ...      | 0.50–0.81  | 0.44–0.65 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T5    | K41545          | 0.15      | 0.30–0.60 | 0.025      | 0.025              | 0.50      | ...      | 4.00–6.00  | 0.45–0.65 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T5b   | K51545          | 0.15      | 0.30–0.60 | 0.025      | 0.025              | 1.00–2.00 | ...      | 4.00–6.00  | 0.45–0.65 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T5c   | K41245          | 0.12      | 0.30–0.60 | 0.025      | 0.025              | 0.50      | ...      | 4.00–6.00  | 0.45–0.65 | ...       | ...           | ...       | ...         | ...      | ...       | 4xC–0.70       |
| T9    | K90941          | 0.15      | 0.30–0.60 | 0.025      | 0.025              | 0.25–1.00 | ...      | 8.00–10.00 | 0.90–1.10 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T11   | K11597          | 0.05–0.15 | 0.30–0.60 | 0.025      | 0.025              | 0.50–1.00 | ...      | 1.00–1.50  | 0.44–0.65 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T12   | K11562          | 0.05–0.15 | 0.30–0.61 | 0.025      | 0.025 <sup>B</sup> | 0.50      | ...      | 0.80–1.25  | 0.44–0.65 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T17   | K12047          | 0.15–0.25 | 0.30–0.61 | 0.025      | 0.025              | 0.15–0.35 | ...      | 0.80–1.25  | 0.15      | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T21   | K31545          | 0.05–0.15 | 0.30–0.60 | 0.025      | 0.025              | 0.50–1.00 | ...      | 2.65–3.35  | 0.80–1.06 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T22   | K21590          | 0.05–0.15 | 0.30–0.60 | 0.025      | 0.025              | 0.50–1.00 | ...      | 1.90–2.60  | 0.87–1.13 | ...       | ...           | ...       | ...         | ...      | ...       | ...            |
| T23   | K40712          | 0.04–0.10 | 0.10–0.60 | 0.030      | 0.010              | 0.50      | ...      | 1.90–2.60  | 0.05–0.30 | 0.20–0.30 | 0.0005–0.0006 | 0.02–0.08 | 0.03        | ...      | 1.45–1.75 | ...            |
| T24   | K30736          | 0.05–0.10 | 0.30–0.70 | 0.020      | 0.010              | 0.15–0.45 | ...      | 2.20–2.60  | 0.90–1.10 | 0.20–0.30 | 0.0015–0.007  | ...       | 0.012       | 0.02     | ...       | Ti             |
| T91   | K90901          | 0.07–0.14 | 0.30–0.60 | 0.020      | 0.010              | 0.20–0.50 | 0.40     | 8.0–9.5    | 0.85–1.05 | 0.18–0.25 | ...           | 0.06–0.1  | 0.030–0.070 | 0.04     | ...       | 0.06–0.10      |
| T92   | K92460          | 0.07–0.13 | 0.30–0.60 | 0.020      | 0.010              | 0.50      | 0.40     | 8.5–9.5    | 0.30–0.60 | 0.15–0.25 | 0.001–0.006   | 0.04–0.09 | 0.030–0.070 | 0.04     | 1.5–2.00  | ...            |
| T122  | K91271          | 0.07–0.14 | 0.70      | 0.020      | 0.010              | 0.50      | 0.50     | 10.0–12.5  | 0.25–0.60 | 0.15–0.30 | 0.0005–0.005  | 0.04–0.10 | 0.040–0.100 | 0.04     | 1.50–2.50 | Cu             |
| T911  | K91061          | 0.09–0.13 | 0.30–0.60 | 0.020      | 0.010              | 0.10–0.50 | 0.40     | 8.5–9.5    | 0.90–1.10 | 0.18–0.25 | 0.0003–0.0006 | 0.06–0.10 | 0.040–0.090 | 0.04     | 0.90–1.10 | ...            |

<sup>A</sup> Maximum, unless range or minimum is indicated. Where ellipses (...) appear in this table, there is no requirement, and analysis for the element need not be determined or reported.

<sup>B</sup> It is permissible to order T2 and T12 with 0.045 max Sulfur. See 14.3.

**6.2 Heat Treatment:**

**6.2.1 Ferritic Alloy and Ferritic Stainless Steels** —The ferritic alloy and ferritic stainless steels shall be reheated for heat treatment in accordance with the requirements of Table 3. Heat treatment shall be carried out separately and in addition to heating for hot forming.

**6.2.2 Austenitic Stainless Steels**—All austenitic tubes shall be furnished in the heat-treated condition, and shall be heat treated in accordance with the requirements of Table 3. Alternatively, immediately after hot forming, while the temperature of the tubes is not less than the specified minimum solution treatment temperature, tubes may be individually quenched in water or rapidly cooled by other means.

**6.3** If any controlled structural characteristics are required, these shall be so specified in the order as to be a guide as to the most suitable heat treatment.

TABLE 2 Chemical Composition Limits, %<sup>A</sup>, for Austenitic and Ferritic Stainless Steel



| Grade                  | UNS Designation | Composition Element |           |            |        |           |           |           |            |                       |           |           |                       |
|------------------------|-----------------|---------------------|-----------|------------|--------|-----------|-----------|-----------|------------|-----------------------|-----------|-----------|-----------------------|
|                        |                 | Manganese           | Carbon    | Phosphorus | Sulfur | Silicon   | Chromium  | Nickel    | Molybdenum | Nitrogen <sup>B</sup> | Niobium   | Titanium  | Other Elements        |
| TP201                  | S20100          | 0.15                | 5.5-7.5   | 0.060      | 0.030  | 1.00      | 16.0-18.0 | 3.5-5.5   | ...        | 0.25                  | ...       | ...       | ...                   |
| TP202                  | S20200          | 0.15                | 7.5-10.0  | 0.060      | 0.030  | 1.00      | 17.0-19.0 | 4.0-6.0   | ...        | .025                  | ...       | ...       | ...                   |
| XM-19 <sup>C</sup>     | S20910          | 0.06                | 4.0-6.0   | 0.045      | 0.030  | 1.00      | 20.5-23.5 | 11.5-13.5 | 1.50-3.00  | 0.20-0.40             | 0.10-0.30 | ...       | V 0.10-0.30           |
|                        | S21500          | 0.06-0.15           | 5.5-7.0   | 0.045      | 0.030  | 0.20-1.00 | 14.0-16.0 | 9.0-11.0  | 0.80-1.20  | ...                   | 0.75-1.25 | ...       | B 0.003-0.009,        |
| <sup>C</sup>           | S25700          | 0.02                | 2.00      | 0.025      | 0.010  | 6.5-8.0   | 8.0-11.5  | 22.0-25.0 | 0.50       | ...                   | ...       | ...       | V 0.15-0.40           |
| TP304                  | S30400          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 8.0-11.0  | ...        | ...                   | ...       | ...       | ...                   |
| TP304L                 | S30403          | 0.035 <sup>D</sup>  | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 8.0-12.0  | ...        | ...                   | ...       | ...       | ...                   |
| TP304H <sup>C</sup>    | S30409          | 0.04-0.10           | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 8.0-11.0  | ...        | ...                   | ...       | ...       | A1 0.003-0.030,       |
|                        | S30432          | 0.07-0.13           | 0.50      | 0.045      | 0.030  | 0.03      | 17.0-19.0 | 7.5-10.5  | ...        | 0.05-0.12             | 0.20-0.60 | ...       | B 0.001-0.010,        |
| TP304N                 | S30451          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 8.0-11.0  | ...        | 0.10-0.16             | ...       | ...       | Cu 2.5-3.5            |
| <sup>C</sup>           | S30453          | 0.035 <sup>D</sup>  | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 8.0-11.0  | ...        | 0.10-0.16             | ...       | ...       | Al 0.8-1.5            |
| <sup>C</sup>           | S30615          | 0.016-0.24          | 2.00      | 0.030      | 0.030  | 3.2-4.0   | 17.0-19.5 | 13.5-16.0 | ...        | ...                   | ...       | ...       | Ce 0.03-0.08          |
| TP309S                 | S30815          | 0.05-0.10           | 0.80      | 0.040      | 0.030  | 1.40-2.00 | 20.0-22.0 | 10.0-12.0 | ...        | 0.14-0.20             | ...       | ...       | ...                   |
| TP309H                 | S30908          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 22.0-24.0 | 12.0-15.0 | ...        | ...                   | ...       | ...       | ...                   |
| TP309Cb                | S30909          | 0.04-0.10           | 2.00      | 0.045      | 0.030  | 1.00      | 22.0-24.0 | 12.0-16.0 | ...        | ...                   | ...       | ...       | 10xC-1.10             |
| TP309Hcb <sup>C</sup>  | S30940          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 22.0-24.0 | 12.0-16.0 | ...        | ...                   | ...       | ...       | 10xC-1.10             |
| <sup>C</sup>           | S31002          | 0.04-0.10           | 2.00      | 0.020      | 0.015  | 0.15      | 24.0-26.0 | 19.0-22.0 | 0.10       | 0.10                  | ...       | ...       | ...                   |
| TP310S                 | S31008          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0 | ...        | ...                   | ...       | ...       | ...                   |
| TP310H                 | S31009          | 0.04-0.10           | 2.00      | 0.045      | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0 | ...        | ...                   | ...       | ...       | ...                   |
| TP310Cb                | S31040          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0 | ...        | ...                   | ...       | ...       | 10xC-1.10             |
| TP310Hcb               | S31041          | 0.04-0.10           | 2.00      | 0.045      | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0 | ...        | ...                   | ...       | ...       | 10xC-1.10             |
| TP310HCbN <sup>C</sup> | S31042          | 0.04-0.10           | 2.00      | 0.045      | 0.030  | 1.00      | 24.0-26.0 | 19.0-22.0 | ...        | 0.15-0.35             | 0.20-0.60 | ...       | ...                   |
| <sup>C</sup>           | S31050          | 0.025               | 2.00      | 0.020      | 0.030  | 0.40      | 24.0-26.0 | 21.0-23.0 | 2.00-3.00  | 0.10-0.16             | ...       | ...       | ...                   |
|                        | S31060          | 0.05-0.10           | 1.00      | 0.040      | 0.030  | 0.50      | 22.0-24.0 | 10.0-12.5 | ...        | 0.18-0.25             | ...       | ...       | Ce + La 0.025-0.070   |
| <sup>C</sup>           | S31254          | 0.020               | 1.00      | 0.030      | 0.010  | 0.80      | 19.5-20.5 | 17.5-18.5 | 6.0-6.5    | 0.18-0.22             | ...       | ...       | B 0.001-0.010         |
| <sup>C</sup>           | S31272          | 0.08-0.12           | 1.50-2.00 | 0.030      | 0.015  | 0.30-0.70 | 14.0-16.0 | 14.0-16.0 | 1.00-1.40  | ...                   | ...       | 0.30-0.60 | Cu 0.50-1.00 B 0.004- |
| TP316                  | S31600          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 16.0-18.0 | 10.0-14.0 | 2.00-3.00  | ...                   | ...       | ...       | ...                   |
| TP316L                 | S31603          | 0.035 <sup>D</sup>  | 2.00      | 0.045      | 0.030  | 1.00      | 16.0-18.0 | 10.0-14.0 | 2.00-3.00  | ...                   | ...       | ...       | ...                   |
| TP316H                 | S31609          | 0.04-0.10           | 2.00      | 0.045      | 0.030  | 1.00      | 16.0-18.0 | 11.0-14.0 | 2.00-3.00  | ...                   | ...       | ...       | ...                   |
| TP316N                 | S31651          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 16.0-18.0 | 10.0-13.0 | 2.00-3.00  | 0.10-0.16             | ...       | ...       | ...                   |
| TP316LN                | S31653          | 0.035 <sup>D</sup>  | 2.00      | 0.045      | 0.030  | 1.00      | 16.0-18.0 | 10.0-13.0 | 2.00-3.00  | 0.10-0.16             | ...       | ...       | ...                   |
| TP317                  | S31700          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 11.0-15.0 | 3.0-4.0    | ...                   | ...       | ...       | ...                   |
| TP317L                 | S31603          | 0.035               | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 11.0-15.0 | 3.0-4.0    | ...                   | ...       | ...       | ...                   |
| TP317LM                | S31725          | 0.03                | 2.00      | 0.045      | 0.030  | 1.00      | 18.0-20.0 | 13.5-17.5 | 4.0-5.0    | 0.20                  | ...       | ...       | Cu 0.75 Cu 0.75       |
| TP317LMN <sup>C</sup>  | S31726          | 0.03                | 2.00      | 0.045      | 0.030  | 1.00      | 17.0-20.0 | 13.5-17.5 | 4.0-5.0    | 0.10-0.20             | ...       | ...       | ...                   |
| <sup>C</sup>           | S32050          | 1.50                | 0.035     | 0.020      | 0.020  | 1.00      | 22.0-24.0 | 20.0-23.0 | 6.0-6.8    | 0.21-0.32             | ...       | ...       | 5(C + N)-0.70         |
| TP321                  | S32100          | 0.08                | 2.00      | 0.045      | 0.030  | 1.00      | 17.0-19.0 | 9.0-12.0  | ...        | ...                   | ...       | ...       | 4(C + N)-0.70         |
| TP321H                 | S32109          | 0.04-0.10           | 2.00      | 0.045      | 0.030  | 1.00      | 17.0-19.0 | 9.0-12.0  | ...        | ...                   | ...       | ...       | 0.70                  |

**TABLE 2** *Continued*

| Grade | UNS<br>Designation | Composition Carbon  |   |         |         |           |           |            |                       | Other<br>Elements |                        |
|-------|--------------------|---------------------|---|---------|---------|-----------|-----------|------------|-----------------------|-------------------|------------------------|
|       |                    | Manganese<br>Carbon | Phospho-<br>Mangane-<br>se<br>phosphate | Sulfur  | Silicon | Chromium  | Nickel    | Molybdenum | Nitrogen <sup>B</sup> |                   |                        |
| 6     | C                  | S32615              | 0.07                                    | 2.00    | 0.045   | 0.030     | 4.8–6.0   | 16.5–19.5  | 19.0–22.0             | 0.30–1.50         | ...                    |
|       | C                  | S33228              | 0.04–0.08                               | 1.00    | 0.020   | 0.015     | 0.03      | 26.0–28.0  | 31.0–33.0             | ...               | 0.60–1.00              |
|       | TP347              | S34565              | 0.030                                   | 5.0–7.0 | 0.030   | 0.010     | 1.00      | 23.0–25.0  | 16.0–18.0             | 4.0–5.0           | 0.40–0.60              |
|       | TP347H             | S34700              | 0.08                                    | 2.00    | 0.045   | 0.030     | 1.00      | 17.0–20.0  | 9.0–13.0              | ...               | 10xC–1.10              |
|       | TP347HFG           | S34709              | 0.04–0.10                               | 2.00    | 0.045   | 0.030     | 1.00      | 17.0–19.0  | 9.0–12.0              | ...               | 8xC–1.10               |
|       | TP347LN            | S34710              | 0.06–0.10                               | 2.00    | 0.045   | 0.030     | 1.00      | 17.0–19.0  | 9.0–12.0              | ...               | 8xC–1.10               |
|       | TP348              | S34751              | 0.005–0.020                             | 2.00    | 0.045   | 0.030     | 1.00      | 17.0–19.0  | 9.0–12.0              | ...               | 0.20–0.50 <sup>E</sup> |
|       | TP348H             | S34800              | 0.08                                    | 2.00    | 0.045   | 0.030     | 1.00      | 17.0–19.0  | 9.0–12.0              | ...               | Co 0.20, Ta<br>0.10    |
|       | TP348H             | S34809              | 0.04–0.10                               | 2.00    | 0.045   | 0.030     | 1.00      | 17.0–19.0  | 9.0–12.0              | ...               | Co 0.20, Ta<br>0.10    |
|       | ...                | S35045              | 0.06–0.10                               | 1.50    | 0.045   | 0.015     | 1.00      | 25.0–29.0  | 32.0–37.0             | ...               | 0.15–0.60              |
| XM-15 | S38100             | 0.08                | 2.00                                    | 0.030   | 0.030   | 1.50–2.50 | 17.0–19.0 | 17.5–18.5  | ...                   | ...               | Al 0.15–0.60           |
|       | TP444              | S44400              | 0.03                                    | 1.00    | 0.040   | 0.030     | 1.00      | 17.5–19.5  | 17.5–2.50             | 0.035             | Cu 0.75                |

<sup>A</sup>Maximum, unless a range or minimum is indicated. Where ellipses (...) appear in this table, there is no minimum and analysis for the element need not be determined or reported.

<sup>B</sup>The method of analysis for Nitrogen shall be a matter of agreement between the purchaser and the producer.

<sup>C</sup>For these alloys, there is no common grade designation. The UNS number uniquely identifies these alloys.

<sup>D</sup>For small diameter or thin walls, or both, where many drawing passes are required, a carbon maximum of 0.040% is necessary in Grades TP304L, TP304LN, TP316L, and TP316LN.

<sup>E</sup>Grade TP347LN shall have an Nb content of not less than 15 times the carbon content.

<sup>F</sup>Grade TP348 shall have an Nb + Ta content of not less than 10 times the carbon content and not more than 1.10%.

<sup>G</sup>Grade TP348H shall have an Nb + Ta content of not less than 8 times the carbon content and not more than 1.10%.

<sup>H</sup>Grade TP444 shall have Ni + Cu = 1.00 max.

<sup>I</sup>Grade TP444 shall have Ti + Nb = 0.20 + 4(C + N)–0.80.

## 7. Chemical Composition

### 7.1 Composition Requirements:

7.1.1 The alloy steels shall conform to the chemical requirements given in Table 1.

7.1.2 The stainless steels shall conform to the chemical requirements given in Table 2.

### 7.2 Product Analysis:

7.2.1 An analysis of either one billet or one tube shall be made from each heat. The chemical composition thus determined shall conform to the requirements specified.

7.2.2 If the original test for product analysis fails, retests of two additional billets or tubes shall be made. Both retests, for the elements in question shall meet the requirements of the specification; otherwise all remaining material in the heat or lot (as described in Section 13) shall be rejected or, at the option of the producer, each billet or tube may be individually tested for acceptance. Billets or tubes that do not meet the requirements of the specification shall be rejected.

## 8. Grain Size

8.1 Grain size shall be as given in Table 3, as determined in accordance with Test Methods E 112.

8.2 Grain size determinations, to demonstrate compliance with 8.1, shall be made on one end of one finished tube from each lot. See 13.1.

## 9. Mechanical Properties

### 9.1 Tensile Requirements:

9.1.1 The material shall conform to the requirements as to tensile properties given in Table 4.

9.1.2 Table 5 gives the computed minimum elongation values for each  $\frac{1}{32}$ -in. [0.8-mm] decrease in wall thickness. Where the wall thickness lies between two values shown in Table 5, the minimum elongation value shall be determined by the following equations. For Grades T23, T24, T91, T92, T122, T911, and S44400:  $E = 32t + 10.00$  [ $E = 1.25t + 10.00$ ]. For all other ferritic alloy grades:  $E = 48t + 15.00$  [ $E = 1.87t + 15.00$ ].

where:

$E$  = elongation in 2 in. [50 mm], %, and

$t$  = actual thickness of specimen, in. [mm].

9.1.3 One tension test shall be made on a specimen from one tube for lots of not more than 50 tubes. Tension tests shall be made on specimens from two tubes for lots of more than 50 tubes. See 13.2.

### 9.2 Hardness Requirements:

9.2.1 The material shall conform to the hardness requirements given in Table 4. See 13.2.

9.2.2 Brinell, Vickers, or Rockwell hardness tests shall be made on specimens from two tubes from each lot. See 13.2.

9.3 *Flattening Test*—One flattening test shall be made on specimens from each end of one finished tube, not the one used for the flaring test, from each lot. See 13.1.

9.4 *Flaring Test*—One flaring test shall be made on specimens from each end of one finished tube, not the one used for the flattening test, from each lot. See 13.1.

9.5 Mechanical property requirements do not apply to tubing smaller than  $\frac{1}{8}$  in. [3.2 mm] in inside diameter or thinner than 0.015 in. [0.4 mm] in thickness.

## 10. Hydrostatic or Nondestructive Electric Test

10.1 Each tube shall be subjected to the nondestructive electric test or the hydrostatic test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.

## 11. Forming Operations

11.1 Tubes, when inserted in a boiler or tube sheet, shall stand expanding and beading without showing cracks or flaws. Superheater tubes when properly manipulated shall stand all forging, welding, and bending operations necessary for application without developing defects. See Note 1.

NOTE 1—Certain of the ferritic steels covered by this specification will harden if cooled rapidly from above their critical temperature. Some will air harden, that is, become hardened to an undesirable degree when cooled in air from high temperatures, particularly chromium-containing steels with chromium of 4 % and higher. Therefore, operations that involve heating such steels above their critical temperatures, such as welding, flanging, and hot bending, should be followed by suitable heat treatment.

## 12. Surface Condition

12.1 Ferritic alloy cold-finished steel tubes shall be free of scale and suitable for inspection. A slight amount of oxidation is not considered scale.

12.2 Ferritic alloy hot-finished steel tubes shall be free of loose scale and suitable for inspection.

12.3 Stainless steel tubes shall be pickled free of scale. When bright annealing is used, pickling is not necessary.

12.4 Any special finish requirement shall be subject to agreement between the supplier and the purchaser.

## 13. Sampling

13.1 For flattening, flaring, and grain size requirements, the term lot applies to all tubes, prior to cutting, of the same size (see 4.1.6) that are produced from the same heat of steel. When final heat treatment is in a batch-type furnace, a lot shall include only those tubes of the same size and from the same heat that are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace or when the heat-treated condition is obtained directly by quenching after hot forming, the number of tubes of the same size and from the same heat in a lot shall be determined from the size of the tubes as prescribed in Table 6.

13.2 For tensile and hardness test requirements, the term lot applies to all tubes prior to cutting, of the same size (see 4.1.6) that are produced from the same heat of steel. When final heat treatment is in a batch-type furnace, a lot shall include only those tubes of the same size and the same heat that are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace, or when the heat-treated condition is obtained directly by quenching after hot forming, a lot shall include all tubes of the same size and heat, heat treated in the same furnace at the same temperature, time at heat, and furnace speed; or all tubes of the same size and heat, hot formed and quenched in the same production run, except as prescribed in 9.1.3.

## 14. Product Marking

14.1 In addition to the marking prescribed in Specification A 450/A 450M, A 1016/A 1016M, the marking shall include

**TABLE 3 Heat Treatment and Grain Size Requirements<sup>A</sup>**

| Grade                              | UNS Number | Heat Treat Type   | Austenitizing/<br>Solutioning<br>Temperature,<br>min or range | Cooling Media             | Subcritical Annealing<br>or Tempering<br>Temperature,<br>min or range °F [°C] | ASTM<br>Grain Size No. <sup>B</sup> |
|------------------------------------|------------|---|---|---------------------------|---|-------------------------------------|
| <b>Ferritic Alloy Steels</b>       |            |   |   |                           |   |                                     |
| T2                                 | K11547     | full or isothermal anneal<br>normalize and temper<br>subcritical anneal | ...<br>...<br>...   | ...<br>...<br>...         | ...<br>...<br>1200 to 1350°F<br>[650 to 730°C]                                | ...                                 |
| T5                                 | K41545     | full or isothermal anneal<br>normalize and temper                       | ...<br>...  | ...<br>...                | 1250°F [675°C]  | ...                                 |
| T5b                                | K51545     | full or isothermal anneal<br>normalize and temper                       | ...<br>...  | ...<br>...                | 1250°F [675°C]  | ...                                 |
| T5c                                | K41245     | subcritical anneal  | ...   | air or furnace            | 1350°F [730°C] <sup>C</sup>   | ...                                 |
| T9                                 | S50400     | full or isothermal anneal<br>normalize and temper                       | ...<br>...  | ...                       | 1250°F [675°C]  | ...                                 |
| T11                                | K11597     | full or isothermal anneal<br>normalize and temper                       | ...<br>...  | ...                       | 1200°F [650°C]  | ...                                 |
| T12                                | K11562     | full or isothermal anneal<br>normalize and temper<br>subcritical anneal | ...<br>...<br>...   | ...<br>...<br>...         | 1200 to 1350°F<br>[650 to 730°C]  | ...                                 |
| T17                                | K12047     | full or isothermal anneal<br>normalize and temper                       | ...<br>...  | ...<br>...                | 1200°F [650°C]  | ...                                 |
| T21                                | K31545     | full or isothermal anneal<br>normalize and temper                       | ...<br>...  | ...<br>...                | 1250°F [675°C]  | ...                                 |
| T22                                | K21590     | full or isothermal anneal<br>normalize and temper                       | ...<br>...  | ...<br>...                | 1250°F [675°C]  | ...                                 |
| T23                                | K40712     | normalize and temper  | 1900°F [1040°C]   | ...                       | 1350°F [730°C]  | ...                                 |
| T24                                | K30736     | normalize and temper  | 1800°F [980°C]  | ...                       | 1350°F [730°C]  | ...                                 |
| T91                                | K90901     | normalize and temper  | 1900°F [1040°C]   | ...                       | 1350°F [730°C]  | ...                                 |
| T92                                | K92460     | normalize and temper  | 1900°F [1040°C]   | ...                       | 1350°F [730°C]  | ...                                 |
| T122                               | K91261     | normalize and temper  | 1900°F [1040°C]   | ...                       | 1350°F [730°C]  | ...                                 |
| T911                               | K91061     | normalize and temper  | 1900 to 1975°F<br>[1040 to 1080°C]                            | D                         | 1365 to 1435°F<br>[740 to 780°C]  | ...                                 |
| <b>Austenitic Stainless Steels</b> |            |   |   |                           |   |                                     |
| TP201                              | S20100     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP202                              | S20200     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| XM-19                              | S20910     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| ...                                | S21500     | solution treatment  | 1900°F [1040°C] <sup>E</sup>                                  | water or other rapid cool | ...   | ...                                 |
| ...                                | S25700     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| ...                                | S30150:    | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP304                              | S30400     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP304L                             | S30403     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP304H                             | S30409     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | 7                                   |
| ...                                | S30432     | solution treatment  | 2000°F [1100°C]   | water or other rapid cool | ...   | ...                                 |
| TP304N                             | S30451     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP304LN                            | S30453     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| ...                                | S30615     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| ...                                | S30815     | solution treatment  | 1920°F [1050°C]   | water or other rapid cool | ...   | ...                                 |
| TP309S                             | S30908     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP309H                             | S30909     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | 7                                   |
| TP309Cb                            | S30940     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP309HCb                           | S30941     | solution treatment  | 1900°F [1040°C] <sup>F</sup>                                  | water or other rapid cool | ...   | 7                                   |
| ...                                | S31002     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP310S                             | S31008     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP310H                             | S31009     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | 7                                   |
| TP310Cb                            | S31040     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP310HCb                           | S31041     | solution treatment  | 1900°F [1040°C] <sup>F</sup>                                  | water or other rapid cool | ...   | 7                                   |
| TP310HCbN                          | S31042     | solution treatment  | 1900°F [1040°C] <sup>F</sup>                                  | water or other rapid cool | ...   | 7                                   |
| ...                                | S31060     | solution treatment  | 1975°F [1080°C]<br>2160°F [1180°C]                            | water or other rapid cool | ...   | 7                                   |
| ...                                | S31254     | solution treatment  | 2100°F [1150°C]   | water or other rapid cool | ...   | ...                                 |
| ...                                | S31272     | solution treatment  | 1920°F [1050°C]   | water or other rapid cool | ...   | ...                                 |
| TP316                              | S31600     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP316L                             | S31603     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP316H                             | S31609     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | 7                                   |
| TP316N                             | S31651     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP316LN                            | S31653     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP317                              | S31700     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| TP317L                             | S31703     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| ...                                | S31725     | solution treatment  | 1900°F [1040°C]   | water or other rapid cool | ...   | ...                                 |
| ...                                | S32050     | solution treatment  | 2100°F [1150°C]   | water or other rapid cool | ...   | ...                                 |

TABLE 3 *Continued*

| Grade                     | UNS Number | Heat Treat Type                  | Austenitizing/<br>Solutioning<br>Temperature,<br>min or range                  | Cooling Media             | Subcritical Annealing<br>or Tempering<br>Temperature,<br>min or range °F [°C] | ASTM<br>Grain Size No. <sup>B</sup> |
|---------------------------|------------|----------------------------------|--|---------------------------|---|-------------------------------------|
| TP321                     | S32100     | solution treatment               | 1900°F [1040°C] <sup>F</sup>   | water or other rapid cool | ...   | ...                                 |
| TP321H                    | S32109     | solution treatment               | cold worked:<br>2000°F [1090°C]<br>hot rolled:<br>1925°F [1050°C] <sup>F</sup> | water or other rapid cool | ...   | 7                                   |
| ...                       | S32615     | solution treatment               | 1900°F [1040°C]  | water or other rapid cool | ...   | 3 or finer                          |
| ...                       | S32716     | solution treatment               | 1900°F [1040°C]  | water or other rapid cool | ...   | ...                                 |
| ...                       | S33228     | solution treatment               | 2050°F [1120°C]  | water or other rapid cool | ...   | ...                                 |
| ...                       | S34565     | solution treatment               | 2050°F [1120°C]–<br>2140°F [1170°C]  | water or other rapid cool | ...   | ...                                 |
| TP347                     | S34700     | solution treatment               | 1900°F [1040°C] <sup>F</sup>   | water or other rapid cool | ...   | ...                                 |
| TP347H                    | S34709     | solution treatment               | cold worked:<br>2000°F [1100°C]<br>hot rolled:<br>1925°F [1050°C] <sup>F</sup> | water or other rapid cool | ...   | 7                                   |
| TP347HFG                  | S34710     | solution treatment, <sup>G</sup> | 2150°F [1175°C]  | water or other rapid cool | ...   | 7-10                                |
| TP347LN                   | S34751     | solution treatment               | 1900°F [1040°C]  | water or other rapid cool | ...   | ...                                 |
| TP348                     | S34800     | solution treatment               | 1900°F [1040°C] <sup>F</sup>   | water or other rapid cool | ...   | ...                                 |
| TP348H                    | S34809     | solution treatment               | cold worked:<br>2000°F [1100°C]<br>hot rolled:<br>1925°F [1050°C] <sup>F</sup> | water or other rapid cool | ...   | 7                                   |
| XM-15                     | S35045     | solution treatment               | 2000°F [1100°C]  | still air cool or faster  | ...   | ...                                 |
|                           | S38100     | solution treatment               | 1900°F [1040°C]  | water or other rapid cool | ...   | ...                                 |
| Ferritic Stainless Steels |            |                                  |  |                           |   |                                     |
| TP444                     | S44400     | subcritical anneal               | ...  | ...                       | 1400°F [760°C]  | ...                                 |

<sup>A</sup> Where ellipses (...) appear in this table there is no requirement.<sup>B</sup> ASTM Grain Size No. listed, or coarser, unless otherwise indicated.<sup>C</sup> Approximately, to achieve properties.<sup>D</sup> Accelerated cooling from the normalizing temperature shall be permitted for section thicknesses greater than 3 in. [75 mm].<sup>E</sup> A maximum solution treating temperature of 2100°F [1150°C] is recommended for UNS S21500.<sup>F</sup> A solution treating temperature above 1950°F [1065°C] may impair resistance to intergranular corrosion after subsequent exposure to sensitizing conditions in the indicated grades. When specified by the purchaser, a lower temperature stabilization or resolution anneal shall be used subsequent to the higher-temperature solution anneal prescribed in this table.<sup>G</sup> Solution treatment shall be preceded by a softening heat treatment prior to cold-working. The softening temperature shall be at least 90°F [50°C] higher than the solution heat treatment temperature, which shall be at 2150°F [1180°C] minimum.

the condition: hot finished or cold finished.

14.2 For the austenitic stainless steels having a grain size requirement (see Table 2) the marking shall also include the heat number and heat-treatment lot identification.

14.3 When either T2 or T12 are ordered with higher sulfur contents as permitted by Note B of Table 1, the marking shall include the letter, S, following the grade designation: T2S or T12S.

## 15. Keywords

15.1 alloy steel tubes; austenitic stainless steel; boiler tubes; ferritic stainless steel; heat exchanger tubes; high-temperature applications; seamless steel tubes; steel tubes; superheater tubes; temperature service applications-high



## A 213/A 213M – 03c4

TABLE 4 Tensile and Hardness Requirements

| Grade   | UNS Designation  | Tensile Strength, min, ksi [MPa] | Yield Strength, min, ksi [MPa] | Elongation in 2 in. or 50 mm, min, % <sup>A,B</sup> | Hardness, Max      |                   |
|---|------------------|----------------------------------|--------------------------------|---|--------------------|-------------------|
|   |                  |                                  |                                |   | Brinell/Vickers    | Rockwell          |
| <i>Low Alloy Steels:</i>                      |                  |                                  |                                |   |                    |                   |
| T5b   | K51545           | 60[415]                          | 30[205]                        | 30  | 179 HBW/<br>190HV  | 89 HRB            |
| T9  | K90941           | 60[415]                          | 30[205]                        | 30  | 179 HBW/<br>190HV  | 89 HRB            |
| T12   | K11562           | 60[415]                          | 32[220]                        | 30  | 163 HBW/<br>170 HV | 85 HRB            |
| T23   | K40712           | 74[510]                          | 58[400]                        | 20  | 220 HBW/<br>230 HV | 97 HRB            |
| T24   | K30736           | 85[585]                          | 60[415]                        | 20  | 250 HBW/<br>265 HV | 25 HRC            |
| T91   | K90901           | 85[585]                          | 60[415]                        | 20  | 250 HBW/<br>265 HV | 25 HRC            |
| T92   | K92460           | 90[620]                          | 64[440]                        | 20  | 250 HBW/<br>265 HV | 25 HRC            |
| T122  | K91271           | 90[620]                          | 58[400]                        | 20  | 250 HBW/<br>265 HV | 25 HRC            |
| T911  | K91061           | 90[620]                          | 64[440]                        | 20  | 250 HBW/<br>265 HV | 25 HRC            |
| All other low alloy grades                    |                  | 60[415]                          | 30[205]                        | 30  | 163 HB/<br>170 HV  | 85 HRB            |
| <i>Austenitic Stainless Steels:</i>           |                  |                                  |                                |   |                    |                   |
| TP201   | S20100           | 95[655]                          | 38[260]                        | 35  | 219 HBW/<br>230 HV | 95 HRB            |
| TP202   | S20200           | 90[620]                          | 45[310]                        | 35  | 219 HBW/<br>230 HV | 95 HRB            |
| XM-19   | S20910           | 100[690]                         | 55[380]                        | 35  | 250 HBW/<br>265 HV | 25 HRC            |
| ...   | S21500           | 78[540]                          | 33[230]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| ...   | S25700           | 78[540]                          | 35[240]                        | 50  | 217 HBW            | 95 HRB            |
| TP304   | S30400           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP304L  | S30403           | 70[485]                          | 25[170]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP304H  | S30409           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| ...   | S30432           | 80[550]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP304N  | S30451           | 80[550]                          | 35[240]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP304LN                                       | S30453           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| ...   | S30615           | 90[620]                          | 40[275]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| ...   | S30815           | 87[600]                          | 45[310]                        | 40  | 217 HBW            | 95 HRB            |
| TP309S  | S30908           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP309H  | S30909           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP309Cb                                       | S30940           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP309HCb                                      | S30941           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| ...   | S31002           | 73[500]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP310S  | S31008           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP310H  | S31009           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP310Cb                                       | S31040           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP310HCb                                      | S31041           | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB            |
| TP310HCbN<br>TP310MoLN<br>T ≤ 0.25 in. [6 mm] | S31042<br>S31050 | 95[655]<br>84[580]               | 43[295]<br>39[270]             | 30<br>25  | 256 HBW<br>217 HBW | 100 HRB<br>95 HRB |



## A 213/A 213M – 03c4

TABLE 4 *Continued*

| Grade                     | UNS Designation | Tensile Strength, min, ksi [MPa] | Yield Strength, min, ksi [MPa] | Elongation in 2 in. or 50 mm, min, % <sup>A,B</sup> | Hardness, Max      |          |
|---------------------------|-----------------|----------------------------------|--------------------------------|---|--------------------|----------|
|                           |                 |                                  |                                |   | Brinell/Vickers    | Rockwell |
| t > 0.25 in. [6 mm]       |                 | 78[540]                          | 37[255]                        | 25  | 217 HBW            | 95 HRB   |
| ...                       | S31060          | 87[600]                          | 41[280]                        | 40  | 217 HBW            | 95 HRB   |
| ...                       | S31254          |                                  |                                |   |                    |          |
| T ≤ 0.187 in. [5 mm]      |                 | 98[675]                          | 45[310]                        | 35  | 220 HBW/<br>230 HV | 96 HRB   |
| T > 0.187 in. [5 mm]      |                 | 95[655]                          | 45[310]                        | 35  | 220 HBW/<br>230 HV | 96 HRB   |
| ...                       | S31272          | 65[450]                          | 29[200]                        | 35  | 217 HBW            | 95 HRB   |
| TP316                     | S31600          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP316L                    | S31603          | 70[485]                          | 25[170]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP316H                    | S31609          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP316N                    | S31651          | 80[550]                          | 35[240]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP317                     | S31700          | 75[515]                          | 30[205]                        | 34  | 192 HBW/<br>200 HV | 90 HRB   |
| TP317L                    | S31703          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S31725          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S32050          | 98[675]                          | 48[330]                        | 40  | 256 HBW            | 100 HRB  |
| TP321                     | S32100          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP321H                    | S32109          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S32615          | 80[550]                          | 32[220]                        | 25  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S32615          | 80[550]                          | 32[220]                        | 25  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S32716          | 80[240]                          | 35[240]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S32716          | 80[240]                          | 35[240]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S33228          | 73[500]                          | 27[185]                        | 30  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S34565          | 115[790]                         | 60[415]                        | 35  | 241 HBW            | 100 HRB  |
| TP347                     | S34700          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP347H                    | S34709          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP347HFG                  | S34710          | 80[550]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP347LN                   | S34751          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP348                     | S34800          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| TP348H                    | S34809          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| ...                       | S35045          | 70[485]                          | 25[170]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| XM-15                     | S38100          | 75[515]                          | 30[205]                        | 35  | 192 HBW/<br>200 HV | 90 HRB   |
| Ferritic Stainless Steels |                 |                                  |                                |   |                    |          |
| TP444                     | S44400          | 60[415]                          | 40[275]                        | 20  | 217 HBW/ 230 HV    | 96 HRB   |

<sup>A</sup> When standard round 2 in. or 50 mm gage length or smaller proportionally sized specimens with gage length equal to 4D (4 times the diameter) is used, the minimum elongation shall be 22 % for all low alloy grades except T23, T24, T91, T92, T122, and T911; and except for TP444.

<sup>B</sup> For longitudinal strip tests a deduction from the basic minimum elongation values of 1.00 % for TP444, T23, T24, T91, T92, T122, and T911, and of 1.50 % for all other low alloy grades for each  $\frac{1}{32}$ -in. [0.8-mm] decrease in wall thickness below  $\frac{5}{16}$  in. [8 mm] shall be made.



## A 213/A 213M – 03c4

**TABLE 5 Computed Minimum Values<sup>A</sup>**

| Wall Thickness<br>in. | mm         | Elongation in 2 in.<br>or 50 mm, min, %            |                              |
|-----------------------|------------|--|------------------------------|
|                       |            | S4400,<br>T23, T24, T91,<br>T92, T122, and<br>T911 | All Other<br>Ferritic Grades |
| 5/16 [0.312]          | 8          | 20   | 30                           |
| 5/32 [0.281]          | 7.2        | 19   | 29                           |
| 1/4 [0.250]           | 6.4        | 18   | 27                           |
| 7/32 [0.219]          | 5.6        | 17   | 26                           |
| 3/16 [0.188]          | 4.8        | 16   | 24                           |
| 5/32 [0.156]          | 4          | 15   | 23                           |
| 1/8 [0.125]           | 3.2        | 14   | 21                           |
| 3/32 [0.094]          | 2.4        | 13   | 20                           |
| 1/16 [0.062]          | 1.6        | 12   | 18                           |
| 0.062 to 0.035, excl  | 1.6 to 0.9 | 12   | 17                           |
| 0.035 to 0.022, excl  | 0.9 to 0.6 | 11   | 17                           |
| 0.022 to 0.015 incl   | 0.6 to 0.4 | 11   | 16                           |

<sup>A</sup> Calculated elongation requirements shall be rounded to the nearest whole number.

**TABLE 6 Number of Tubes in a Lot Heat Treated by the Continuous Process or by Direct Quench After Hot Forming**

| Size of Tube   | Size of Lot             |
|--|-------------------------|
| 2 in. [50.8 mm] and over in outside diameter and 0.200 in. [5.1 mm] and over in wall thickness | not more than 50 tubes  |
| 2 in. [50.8 mm] and over in outside diameter and under 0.200 in. [5.1 mm] in wall thickness    | not more than 75 tubes  |
| Less than 2 in. [50.8 mm] but over 1 in. [25.4 mm] in outside diameter                         | not more than 75 tubes  |
| 1 in. [25.4 mm] or less in outside diameter  | not more than 125 tubes |

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order.

### S1. Stress-Relieved Annealed Tubes

S1.1 For use in certain corrosives, particularly chlorides where stress corrosion may occur, tubes in Grades TP304L, TP316L, TP321, TP347, and TP348 may be specified in the stress-relieved annealed condition.

S1.2 When stress-relieved tubes are specified, tubes shall be given a heat treatment at 1500 to 1650°F [815 to 900°C] after roll straightening. Cooling from this temperature range may be either in air or by slow cooling. No mechanical straightening is permitted after the stress-relief treatment.

S1.3 Straightness of the tubes shall be a matter of negotiation between the purchaser and supplier.

### S2. Stabilizing Heat Treatment

S2.1 Subsequent to the solution anneal required in Section 6, Grades TP309HCb, TP310HCb, TP310HCbN, TP321, TP321H, TP347, TP347H, TP348, and TP348H shall be given a stabilization heat treatment at a temperature lower than that used for the initial solution annealing heat treatment. The temperature of stabilization heat treatment shall be at a temperature as agreed upon between the purchaser and vendor.

### S3. Unstraightened Tubes

S3.1 When the purchaser specifies tubes unstraightened after final heat treatment (such as coils), the minimum yield strength of Table 3 shall be reduced by 5 ksi [35 MPa].

S3.2 On the certification, and wherever the grade designation for unstraightened tubing appears, it shall be identified with the suffix letter "U" (for example, 304-U, 321-U, etc.).

### S4. Intergranular Corrosion Test

S4.1 When specified, material shall pass intergranular corrosion tests conducted by the manufacturer in accordance with Practices A 262, Practice E.

NOTE S4.1—Practice E requires testing on the sensitized condition for low carbon or stabilized grades, and on the as-shipped condition for other grades.

S4.2 A stabilization heat treatment in accordance with Supplementary Requirement S2 may be necessary and is permitted in order to meet this requirement for the grades containing titanium or columbium, particularly in their H versions.

## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard specification since the last issue, A 213/A 213M – 03bc, that may impact the use of this standard specification. (Approved October March 1, 2003)

- (1) Replaced Specification A 450/A 450M with Specification A 1016/A 1016M in Sections 2, 3, and 14.
- (2) Editorially revised Sections 3 and 13.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 213/A 213M – 03b, that may impact the use of this specification. (Approved October 1, 2003)

- (1) Added S31060 to Tables 2, 3 and 4.
- (2) Revised 7.1.1 and 7.1.2.
- (3) In Table 1, revised the table title, re-oriented the table, deleted S44400, added UNS numbers, revised Columbium to Niobium, moved the column for Ti to the column for Other Elements, established new columns for B, N, Al, and W, addressed maximum limits and ellipses (...) with a global footnote, and incorporated the footnote for the Ti content of T5c into the table.
- (4) Revised 8.1.
- (5) Revised 9.1.1, 9.1.2, and 9.2.1 editorially.
- (6) Corrected 9.5 to insert words that had been inadvertently deleted in the previous edition.
- (7) In Table 2, revised the table title, re-oriented the table so that grades appear in the first column and the element headings appear in a row at the top of the table, sorted the table by order

of UNS number, inserted grade names for S31050, S31725, and S31726, inserted a UNS number for TP347HFG, included TP444, UNS S44400 in the table, moved the rows for Cb + Ta and Ta to footnotes, moved the row for Ce to the column for Other Elements, established a column for Niobium and removed Cb from the row for Other Elements; and addressed maximum limits and ellipses (...) with a global footnote.

- (8) In Table 3, inserted UNS numbers for T24 and T911, inserted the Grade for S44400, and deleted redundant lines.
- (9) In Table 4, changed the subtitles of the subsections of the table, inserted UNS numbers for the low alloy steels where they were missing, deleted the row for TP7 which was removed from the specification previously, changed the unit name for Brinell hardness to HBW, and sorted the stainless steels in order of UNS number.

Committee A01 has identified the location of selected changes to this standard specification since the last issue, A 213/A 213M – 03a, that may impact the use of this standard specification. (Approved September 10, 2003)

- (1) Added UNS S35045 to Tables 2, 3 and 4.

Committee A01 has identified the location of selected changes to this standard specification since the last issue, A 213/A 213M – 03, that may impact the use of this standard specification. (Approved April 10, 2003)

- (1) Added UNS S31254 to Tables 2, 3 and 4.

Committee A01 has identified the location of selected changes to this standard specification since the last issue, A 213/A 213M – 01a, that may impact the use of this standard specification. (Approved Feb. 10, 2003)

- (1) Revised stainless steel chemistry table to conform to Guide A 959.
- (2) Referenced Terminology A 941 for definitions and removed definitions redundant with Terminology A 941.
- (3) Clarified meaning of ellipses in tables.
- (4) Moved lot definitions into the text.
- (5) Deleted requirements that are in Specification A 450/A 450M.
- (6) Revised organization to conform to Guide A 994.
- (7) Tabularized heat treatment requirements.
- (8) Tabularized grain-size requirements of stainless steels.
- (9) Added UNS numbers.
- (10) Corrected the name of Grade 18Cr-2Mo to Grade 444, UNS S44400, and changed its location to the table for stainless steels.
- (11) Clarified the requirement to reheat all of the ferritic alloy and ferritic stainless steels before heat treatment.
- (12) Integrated the product analysis of Grade 91 with the heat analysis.
- (13) Clarified that the tension test specimen is from one tube for lots of 50 tubes or less.
- (14) Deleted paragraph 11.5, which was in conflict with Section 12.
- (15) Considered higher chromium content steels than 9 % Cr in old Note 4, which is now new Note 1.
- (16) Added Vickers hardness tests to 11.4.

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website ([www.astm.org](http://www.astm.org)).*